ATTACHMENTS

Attachment A

Methods for Characterizing Persistence

1 Definition and Measures Used to Characterize Persistence

EPA (1998) defined "persistence" as "...the tendency of a chemical to remain in the environment without transformation or breakdown into another chemical form. Persistence indicates how long a chemical is expected to exist in the environment and, thus, be available for exposure..."

There are two types of chemical-specific measures commonly used to characterize a chemical's persistence. These two types of measures were discussed at the September 8th PBT Advisory meeting and include:

- **Regional Half-Lives***:* EPA used the multi-media equilibrium criterion (EQC) model to estimate a regional half-life which they used to characterize the persistence of individual chemicals. The EQC model is a steady-state non-equilibrium multi-media partitioning model developed by Donald Mackay (Mackay, 1992, 1995). Input requirements for the model include (1) measured half-life data for air, water, soil, and sediment; (2) models predicting estimated degradation times, (3) a model predicting hydrolysis half-life values for chemicals, and (4) other physical-chemical properties. Results for the model are expressed as a regional persistence residence time (regional half-life) and the estimated percent of each portion of the area modeled. For purposes of the WMPT evaluation, EPA developed an Excel spreadsheet to perform calculations equivalent to the EQC model. Specifically, the EQC model equations (which are expressed in terms of "fugacity" (i.e. escaping tendency)) were rewritten in terms of chemical concentrations. Other multi-media environmental models could also be used to estimate regional half-life values.[1]
- **Media-Specific Half Lives**: Most environmental organizations[2] have used information on the environmental half-live in the air, surface water, soils or sediment to characterize the persistence of individual chemicals. "Environmental half-live" means the time required for the concentration of a chemical to diminish to half its original value. Estimates of environmental half-life values for individual chemicals can be based on either (1) measurements from field or laboratory studies or (2) predictions based on various computer models. Sources of information on environmental half-life values for

[1] The EQC multi-media model was developed by Donald Mackey (Mackey et al. 1992) and is commonly used to evaluate the environmental fate of chemicals at level 3 (steady state, non-equilibrium conditions). The modeled environment is considered to be more broadly applicable than other level 3 models (e.g., CalTOX). The model has undergone peer review and is generally accepted by academic and industry modeling experts. EPA conducted an extensive review (including consultation with outside modeling experts) before concluding that the EQC model was sufficient for purposes of performing screening level analyses. In general, the use of multi-media models is widely supported and EPA has worked with its Science Advisory Board to develop a state of the art model for evaluating multimedia chemical fate and transport (e.g., Total Risk Integrated Model (TRIM)) which was not available at the time the WMPT was being developed.

[2] Examples of approaches/programs that have used media-specific environmental half-life values to characterize persistence of individual chemicals include: (1) Amendments to the Toxics Release Inventory Rule to address PBT chemicals); (2) Stockholm Convention on Persistent Organic Pollutants; (3) Canadian Toxics Substances Management Programme; and (4) Great Lakes Binational Toxics Strategy/EPA National PBT Strategy.

individual chemicals are summarized in Table 1 below. Media-specific environmental half-life values are input parameters for the EQC and other multi-media models.

2 Sources of Information to Characterize Persistence

There are several sources of information that can be used to characterize environmental half-life values. That information can be used in two ways: (1) input parameters for multi-media models that predict regional half-lives (or similar measures); or (2) measures of persistence (e.g. surface water half life).

In developing the WMPT, EPA reviewed a wide range of sources of information on environmental half-lifes. Based on that review, EPA identified five sources of information they believed provided a sufficient basis for characterizing and ranking the persistence of individual chemicals. EPA reviewed these sources and assigned data preferences (highest, high, medium, low, lowest) to those information sources. The data hierarchy/preferences developed by EPA were based on several attributes of the underlying data: (1) extent to which information reflects agency consensus; (2) extent to which data is peer-reviewed; (3) the frequency which values are updated; (4) the extent and quality of documentation; (5) how current the data were; and (6) copyright issues. In general:

- EPA assigned higher preferences to sources of measured values than to sources of predicted values;
- EPA assigned higher preferences to sources of information that had undergone scientific peer review.

The information sources used by EPA in preparing the WMPT and data preferences assigned to those sources are summarized in Table 1.

Table A1: Data Preferences for Sources of Media-Specific Half-Life Values

(M= Measured Data; P = Predicted Data)

Source	Air	Water	Soil	Sediment	EPA Data Preference
Handbook of Environmental Degradation Rates (Howard et al.)	M	M	M	M	Highest
Illustrated Handbook of Physical-Chemical Properties and Environmental Fate of Organic Chemicals (Mackay et al.)	M	M	M	M	High
Agricultural Research Service (ARS) Pesticides Properties Data Based			M	M	Medium
EPIWIN (Estimation Programs Interface for Windows 3.1) (Syracuse Research Corp.)	P	P	P	P	Low
Ultimate Survey Model		P	P	P	Low

3 Range of Values Used to Characterize Environmental Persistence

There are significant differences in the bioaccumulation potential for individual chemicals or chemical groups. To provide a sense of the range of values and differences, Ecology compiled and reviewed the information on environmental persistence for the chemicals or chemical groups that had previously been identified as PBT chemicals by one or more organizations (See Attachment 1).

- Regional half life values were available for 84 of the chemicals or chemical groups. Values ranged from 127 to 39,526 hours. Seventy-six (76) of the 84 chemicals had regional half life values above 580 hours. The distribution of reported values is summarized in Table 2.

Table A2: Range of Range of Regional Half Live Values for 84 Chemicals That Appear on One or More PBT Lists

Number of Values	84
Range of Values	127 to 39,526
10^{th} Percentile	590
25^{th} Percentile	1,268
50^{th} Percentile	2,134
75^{th} Percentile	3,800
90^{th} Percentile	12,874

- Surface water half life values were available for 80 of the chemicals or chemical groups. Values ranged from 1 to 3,300 days.
    - Forty five (45) of the 80 chemicals had surface water half life values equal to or greater than 60 days (2 months) which is the persistence criterion used by several programs including the Stockholm Convention, the European Union PBT criteria and the EPA Toxics Release Inventory (TRI).
    - Fifteen (15) of the 80 chemicals had surface water half life values equal to or greater than 180 days (6 months) which is the persistence criterion used by several programs including the Canada Toxic Substances Management Programme.
- Soil half life values were available for 83 of the chemicals or chemical groups. Values ranged from 9 to 7,200 days.
    - Seventy (70) of the 83 chemicals had soil half life values equal to or greater than 60 days (2 months) which is the persistence criterion used by EPA to identify chemicals for reporting as part of the EPA Toxics Release Inventory (TRI) program.

- Fifty (50) of the 83 chemicals had soil half life values equal to or greater than 180 days (6 months) which is the persistence criterion used by several programs including the Stockholm Convention, the European Union PBT criteria and the Canada Toxic Substances Management Programme.

Attachment B

Methods for Characterizing Bioaccumulation Potential

1 Definitions and Measures Used to Characterize Bioaccumulation Potential

EPA (1998) specifies that "...[b]ioaccumulation potential is the capacity of a chemical to increase in concentration or accumulate (be stored in tissue) in an organism as a result of uptake from all environmental sources over a period of time .... Bioaccumulation potential indicates the degree to which a chemical is accumulated by living organisms to higher concentrations (sometimes much higher) than in the surrounding environmental media. It also indicates the degree to which chemical concentrations (and thus exposures) may be magnified in food webs..." (p. 4-1)[3]

There are several chemical-specific measures commonly used to characterize a chemical's bioaccumulation potential. These include:

- **"Bioaccumulation factor" or "BAF"** is the ratio of the concentration of a chemical in an organism to the concentration of the chemical in the surrounding environment. The BAF is a measure of the extent to which the organism accumulates the chemical as a result of uptake through ingestion as well as contact from contaminated media, such as water.[4] A high BAF value indicates a high potential for bioaccumulation. As discussed in the next section, BAF values for individual chemicals may be obtained from several sources and may be based on either (1) measured values based on field or laboratory studies or (2) predicted values generated using standard models and information on chemical characteristics (e.g. Log Kow).
- **"Bioconcentration factor" or "BCF"** is the ratio of the concentration of a chemical in an organism to the concentration of the chemical in the surrounding environment. The BCF is a measure of the extent of chemical partitioning between and their surrounding environment. The BCF does not evaluate uptake through the diet, only through contact with environmental media.[5] From a practical standpoint, most available information on bioconcentration is based on aquatic ecosystems and processes where there is a net accumulation of a chemical directly from water to aquatic organisms resulting from simultaneous uptake (e.g., by gill or epithelial tissue) and elimination. In this sense,

[3] This definition of bioaccumulation potential is included in technical support document for the Waste Minimization Prioritization Tool. EPA and other scientific and regulatory organizations have adopted similar definitions in other rules and guidance materials. For example, the preamble to the rule amending the TRI list to incorporate several PBT chemicals defines "Bioaccumulation" as a process by which organisms accumulate a chemical in their body as a result of uptake from all environmental sources. All of the definitions include several common concepts of (1) a process, (2) accumulation in organisms; (3) increasing concentrations; and (4) uptake from multiple sources.

[4] The draft definition was taken from the WMPT technical support document (EPA 1998) which references the Hazardous Waste Identification Rule. It is consistent with other standard definitions of the term found in other laws, treaties, guidance materials and textbooks and captures the concepts of (1) ratio of concentrations in tissue and surrounding media; (2) uptake from all environmental media or sources; (3) it is a measure of bioaccumulation or bioaccumulation potential.

[5] This definition was taken from the WMPT technical support document (EPA 1998) which references the Hazardous Waste Identification Rule. It is consistent with other standard definitions of the term found in other laws, treaties, guidance materials and textbooks and captures the concepts of (1) ratio of concentrations in tissue and surrounding media; (2) partitioning between organism and environmental media; (3) it is a measure of bioaccumulation or bioaccumulation potential.

bioconcentration represents the first step in the bioaccumulation/biomagnification[6] process.

- **"Log Octanol-Water Partition Coefficient" or Log K_{ow}"** is an acronym for octanol-water partition coefficient. This is a ratio of the concentration of a substance in an n-octanol phase to its concentration in the aqueous phase in an equilibrated two-phase n-octanol-water system. It is a measure of how likely a chemical is to partition into lipids (fat) and, consequently, can be used to predict bioconcentration. Some organizations used Log Kow as an additional measure for judging bioaccumulation potential.[7].
- **"Biota-Sediment Accumulation Factors" or "BSAFs"** is the relative concentration of a substance in the tissues of an organism compared to the concentration of the same substance in the sediment (EPA, 2000).[8] BSAFs are typically developed on a site- or species-specific basis and, consequently, take into account metabolism, growth and bioavailability. When preparing the WMPT, EPA (1998) did not use BSAF values to characterize bioaccumulation potential. However, there are equations for using BSAF values to estimate BAF values. It appears that EPA considered such information when assigning BAF values to individual chemicals.

2 Sources of Information Used to Characterize Bioaccumulation Potential

A wide range of information sources provide information that can be used to characterize bioaccumulation potential (BAF values, BCF values, etc.). In developing the WMPT, EPA reviewed a wide range of sources of information that could be used to characterize the bioaccumulation potential of individual chemicals or groups of chemicals. Based on that review, EPA identified eight (8) sources of information that they thought provided a sufficient basis for characterizing and ranking the bioaccumulation potential of individual chemicals or chemical groups. EPA reviewed those 8 sources and assigned data preferences (highest, high, medium, low, lowest) to each source. The data hierarchy/preferences developed by EPA were based on several attributes of the underlying data: (1) extent to which information reflects agency consensus; (2) extent to which data is peer-reviewed; (3) the frequency which values are updated; (4) the extent and quality of documentation; (5) how current the data were; and (6) copyright issues. In general:

- EPA assigned higher preferences to sources of BAF values than to sources of BCF values;
- EPA assigned higher preferences to sources of measured BAF or BCF values than to sources of BAF or BCF values predicted using various models; and

[6] Biomagnification occurs when the processes of bioconcentration and bioaccumulation result in increasing tissue concentrations as a chemical moves up the food web (e.g., moves up two or more trophic levels). The term implies an efficient transfer of chemical from food to consumer, so that residue concentrations increase systematically from one trophic level to another.

[7] For example, the bioaccumulation criteria in the Stockholm Convention are (1) BAF or BCF > 5000 or (2) Log Kow > 5.

[8] A more technical definition is provided in EPA (1995) which states that BSAFs are "...the ratio of a substance's lipid normalized concentration in tissue of an aquatic organism to it's organic carbon-normalized concentration in surface sediment, in situations where the ratio does not change substantially over time, both the organism and it's food are exposed, and the surface sediment is representative of average surface sediment in the vicinity of the organisms.

The information sources used by EPA in preparing the WMPT and data preferences assigned to those sources are summarized in Table 4.

Table B1: Sources of Information on Bioaccumulation Potential Used to Prepare WMPT

Data Source	Data Element	Data Preference
Hazardous Waste Identification Rule (Draft)	Measured BAF	Highest
Mercury Report to Congress	Measured BAF	Highest
Hazardous Waste Identification Rule (Draft)	Measured BCF	High
Ambient Water Quality Criteria Documents	Measured BCF	High
Syracuse Research Corp. ISIS BCF File	Measured BCF	High
Hazardous Waste Identification Rule (draft)	Predicted BAF	Medium
Hazardous Waste Identification Rule	Predicted BCF	Low
BCFWIN	Predicted BCF	Low

Since 1998, other sources of information have been developed and are available in the scientific literature or through various databases. These include: (1) risk profiles prepared for individual chemicals by the World Health Organization, the European Union or the United Nations Environmental Program; (2) information on BAF values compiled by the Oakridge National Laboratory; and (3) bioaccumulation information compiled in the ECOTOX database maintained by the Environmental Protection Agency.

3 Range of Values Used to Characterize Bioaccumulation Potential

There are significant differences in the bioaccumulation potential for individual chemicals or chemical groups. To provide a sense of the range of values and differences, Ecology compiled and reviewed the information on bioaccumulation potential for chemicals or chemical groups that had previously been identified as PBT chemicals by one or more organizations (See Attachment 1).

- BAF or BCF values were available for 85 chemicals or chemical groups. Values ranged from 112 to 40,000,000. Information on the distribution of BAF/BCF values is summarized in Table 5.

Table B2: Range of BAF or BCF Values for 85 Chemicals Appearing on One or More PBT Lists	
Number of Values	85
Range of Values	112 to 40,000,000
10th Percentile	806
25th Percentile	2,399
50th Percentile	8,128
75th Percentile	19,952
90th Percentile	32,908
Values > 1000	72
Values > 5000	51

- Ecology also compiled the information used by EPA to characterize bioaccumulation potential for the 142 chemicals that received PBT scores of nine (9) using the WMPT scoring algorithm. The range and distribution of values used by EPA for these 142 chemicals (see Table 6) are similar to the range and distribution of values for the 80 chemicals appearing on one or more PBT lists. This was expected given that most of the 80 chemicals also received PBT scores of nine (9).

Table B3: Range of BAF or BCF Values for 166 Chemicals With PBT Scores of Nine or Appearing on One or More PBT Lists	
Number of Values	166
Range of Values	112 to 40,000,000
10th Percentile	1,023
25th Percentile	1,995
50th Percentile	5,623
75th Percentile	1,6042
90th Percentile	27,318

Attachment C

Methods for Characterizing Toxicity (Non-Cancer Health Effects)

1 Definitions and Measures Used to Characterize Human Toxicity (Non-Cancer Health Effects)

Toxicity is a measure of a chemical's potential to cause adverse effects to living organisms. The approach used by the Department of Ecology to characterize toxicity is based on the framework developed by EPA as part of the Waste Minimization Prioritization Tool and considers three toxicity measures: (1) human toxicity (non-cancer health effects); (2) human toxicity (carcinogenic effects); and (3) ecological toxicity. With respect to non-cancer health effects, Ecology routinely considers the potential for acute toxicity and chronic toxicity. These terms are defined in the Model Toxics Control Act Cleanup Regulation:

- **"Acute toxicity"** means the ability of a hazardous substance to cause injury or death to an organism as a result of short-term exposure to a hazardous substance.
- **"Chronic toxicity"** means the ability of a hazardous substance to cause injury or death to an organism resulting from repeated or constant exposure to the hazardous substance over an extended period of time.

There are several chemical-specific measures commonly used to characterize a chemical's potential to cause non-cancer health effects in humans.

- **"Reference doses"** or **"RfDs"** are duration-specific estimates (with uncertainty spanning perhaps an order of magnitude) of a daily exposure to the human population (including sensitive groups) that is likely to be without an appreciable risk of deleterious effects – even in sensitive individuals. Reference doses are derived from the "No-observed-adverse-effect level" (NOAEL) or "Lowest-observed-adverse-effect level" (LOAEL) observed in human or animal studies by consistent application of uncertainty factors.
- **"Reference concentrations"** or **"RfCs"** are estimates of the highest inhaled air concentration exposure for the human population that is likely to be without appreciable risk of deleterious effects during a lifetime.
- **"Minimal risk levels"** or **"MRLs"** are published by the Agency for Toxic Substances and Disease Registry (ATSDR) using methods that are similar to the methods used by EPA to develop Reference Doses and Reference Concentrations. ATSDR states that "...[a]n MRL is an estimate of the daily human exposure to a hazardous substance that is likely to be without appreciable risk of adverse noncancer health effects over a specified duration of exposure. MRLs may be developed for acute exposure durations (1-14 days), intermediate exposure durations (>14-364 days) and chronic exposure durations (365 days or longer).

EPA considered several other toxicity measures to characterize human toxicity due to non-cancer health effects (e.g No observable effects levels/ Lowest observable effect levels (NOAELs/LOAEL), Reportable quantities (RQ), etc). The other measures considered by EPA are listed in Table C1, but not discussed further since they were rarely used to

characterize toxicity of the universe of chemicals considered in the comparison described in Section 2 of this handout.

2 Sources of Information Used to Characterize the Potential for Human Toxicity (Non-cancer Health Effects)

There are several readily available sources of information on human toxicity measures that can be used to characterize human toxicity (non-cancer health effects). When developing the WMPT, EPA used several types of measures related to a chemical's capacity to cause acute and chronic adverse effects in human receptors and the magnitude and severity of those effects (e.g., RfD) to assign toxicity scores. As part of that process, EPA also reviewed the quality and attributes of those information sources and assigned data preference rankings (highest, high, medium, low, lowest) to each source. The EPA data hierarchy preferences or rankings were based on several attributes of the underlying data: (1) extent to which information reflects agency consensus; (2) extent to which data is peer-reviewed; (3) the frequency which values are updated; (4) the extent and quality of documentation; (5) how current the data were; and (6) copyright issues. In general:

- EPA assigned higher preferences to RfD and RfD values published in the IRIS database than RfD and RfC values from the HEAST tables.
- EPA assigned higher preferences to RfD and RfD values (or similar values such as MRLs) that take into account uncertainties associated with extrapolating study results to human populations than study results (NOAELs or LOAELs) that do not specifically address such uncertainties.
- EPA assigned higher preferences to information where toxicity measures are expressed in terms of dose (e.g. mg/kg/day) than measures based on other quantitative or qualitative measures (e.g. the 1,2, 3 scores used to evaluate submissions under Section 8(e) of the Toxics Substances Control Act.

The information sources used by EPA in preparing the WMPT and data preferences assigned to those sources are summarized in Table C1.

Table C1 Sources of Information on Human Toxicity (Non-Cancer Health Effects) Used to Prepare WMPT		
Data Source	Data Element	Data Preference
Integrated Risk Information System (IRIS) – Environmental Protection Agency	Reference Doses Reference Concentrations	Highest
Minimal Risk Levels – Agency for Toxics Substances and Disease Registry	MRL – Oral MRL - Inhalation	High
Health Effects Assessment Summary Tables (HEAST) – Environmental Protection Agency	Reference Doses Reference Concentrations	High
Reportable Quantities (RQ) – Environmental Protection Agency	RQ Values	Medium
TSCA Section 4 Guidelines – Environmental Protection Agency	Sub-chronic NOAEL Sub-chronic LOAEL Developmental NOAEL Developmental LOAEL	Medium
Reference Exposure Level (REL)	REL	Medium
TSCA 8(e) Submissions	Score of 1, 2 or 3	Low
CESARS[9] Oral Mammalian Sublethality Score	Score 1 through 10	Low
Human Health Structure Activity Team Rank	High, Medium, Low	Low

There are other readily available sources of human toxicity measures that are used by other organizations when evaluating the potential for adverse effects. In most cases, the toxicity measures rely upon the same toxicological information and studies used by EPA or ATSDR to develop reference doses etc. However, there are some differences in the methods used to calculate toxicity measures (e.g. selection of uncertainty factors, identification of points of departure for applying uncertainty factors) that can result in toxicity measures that differ from those published by EPA. Other readily available sources of information human toxicity measures include: (1) the California Office of Environmental Health Hazard (OEHHA); (2) the National Research Council; (3) Risk Profiles prepared to support listing decisions pursuant to the Stockholm Convention; (4) the World Health Organization; and (5) the peer-reviewed scientific literature.

[9] **Chemical Evaluation Search and Retrival System (CESARS):** CESARS is a database developed by the Canadian Center for Occupational Health and Safety and the Michigan Department of Natural Resources. As of 1998, the database included physical-chemical information, summaries of published information and health and ecological toxicity information for 851 chemicals.

3 Range of Values Used to Characterize the Potential for Human Toxicity (Non-cancer Health Effects)

There are significant differences in the toxicity measures individual chemicals or chemical groups. To provide a sense of the range of values and differences, Ecology compiled and reviewed the information on human toxicity (non-cancer health effects) for chemicals or chemical groups that had previously been identified as PBT chemicals by one or more organizations (See Table 1 in main document).

- Available Information on Carcinogenicity: Out of ninety-one (91)chemicals/chemical groups, 56 had some quantitative or semi-quantitative information available on non-cancer health effects. The 56 chemicals/chemical groups included three metals (mercury, lead and cadmium).
- Range of Values: Reference doses or equivalent measures were available for 44 of the chemicals/chemicals groups and ranged from 0.000000001 to 0.8 mg/kg/day.
    - Twenty-five chemicals or chemical groups had toxicity measures that exceeded the EPA fenceline value (0.0006 mg/kg/day). Two additional chemicals had toxicity measures that exceeded the EPA fencelines: benzo(a)pyrene had an RQ score of 10; and toxaphene had a CESAR score of 10.
    - A decision to increase the fenceline values would increase the number of chemicals or chemical groups meeting the toxicity criteria based on non-cancer health effects. For example, if the fenceline values were raised from 0.0006 mg/kg/day to 0.003 mg/kg/day (a 5-fold increase), six additional chemicals or chemical groups would meet the criteria.
- Data Quality Hierarchy: Information used to characterize the chemicals considered in this evaluation was obtained from sources that EPA rated at the higher end of their data hierarchy:
    - IRIS Database (Highest) = 33 chemicals or chemical groups;
    - MRL or HEAST Database (High) = 15 chemicals or chemical groups; and
    - Other (California Environmental Protection Agency, CESARS, RQ values) (Medium or Low) = 8 chemicals or chemical groups.

Table C2 - Human Toxicity (Non-Cancer)				
Data Element/Source	High (3)	Medium (2)	Low (1)	Data Preference
IRIS Reference Dose	< 0.0006	0.0006 - 0.06	> 0.06	Highest
IRIS Reference Concentration	< 0.002	0.002 - 0.2	> 0.2	Highest
Minimal Risk Level (MRL) -- Oral	< 0.0006	0.0006 - 0.06	> 0.06	High
Minimal Risk Level (MRL) - Inhalation	< 0.002	0.002 - 0.2	> 0.2	High
HEAST Reference Dose (RfD)	< 0.0006	0.0006 - 0.06	> 0.06	High
HEAST Inhalation Conc. (RfC)	< 0.002	0.002 - 0.2	> 0.2	High
Reportable Quantity (RQ)	< or = 10	100, 1000	> or = 5000	Medium
TSCA 4 Subchronic NOAEL	< 0.6	0.6 - 60	> 60	Medium
TSCA 4 Subchronic LOAEL	< 6	6 - 600	> 600	Medium
TSCA 4 Developmental NOAEL	< 50	50 - 250	> 250	Medium
TSCA 4 Developmental LOAEL	< 500	500 - 2500	> 2500	Medium
Reference Exposure Level (REL)	< 2	2 - 200	> 200	Medium
TSCA 8(e) Submission	3	2	1	Low
CESARS Oral Mammalian Sublethality Score	> or = 8	6, 4	< or = 2	Low
Human Health Structure Activity Team Rank	High	Medium	Low	Lowest

Attachment D

Methods for Characterizing Toxicity (Carcinogenic Effects)

1 Definitions and Measures Used to Characterize Carcinogenicity

Toxicity is a measure of a chemical's potential to cause adverse effects to living organisms. The approach used by the Department of Ecology to characterize toxicity is based on the framework developed by EPA as part of the Waste Minimization Prioritization Tool and considers three toxicity measures: (1) human toxicity (non-cancer health effects); (2) human toxicity (carcinogenic effects); and (3) ecological toxicity. With respect to carcinogenic health effects, Ecology routinely considers (1) the weight of evidence to support identifying a chemical as a carcinogen and (2) the relative potency of the chemical measured in terms of a slope factor or similar measure.

Ecology has defined the term "carcinogen" in several rules. For example, the Model Toxics Control Act includes the following definition:

> "Carcinogen" means any chemical or agent that produces or tends to produce cancer in humans. For implementation of this chapter, the term carcinogen applies to chemicals on the United States Environmental Protection Agency lists of A (known human) and B (probable human) carcinogens, and any chemical that causes a significant increased incidence of benign or malignant tumors in a single, well conducted animal bioassay, consistent with the weight of evidence approach specified in the United States Environmental Protection Agency's Guidelines for Carcinogen Risk Assessment as set forth in 51 FR 33992 et seq.[10]

There are several chemical-specific measures commonly used to characterize a chemical's potential to cause carcinogenic health effects in humans.

- **"Cancer Slope Factors"** or **"Cancer Potency Factors"** are used to characterize the relationship between exposure to a substance and the increased likelihood of developing cancer. The slope factor is used to estimate the probability (upper bound) that an individual will develop cancer as a result of exposure to a potential carcinogen. Slope factors are developed from the dose-response curves observed in human or animal studies.
- **"Unit Risk"** values are estimates of the highest inhaled air concentration exposure for the human population that is likely to be without appreciable risk of deleterious effects during a lifetime.

2 Sources of Information Used to Characterize the Potential for Human Toxicity (Carcinogenic Health Effects)

There are several readily available sources of information on carcinogenic health effects. When developing the WMPT, EPA considered information on the weight of evidence and the magnitude and severity of those effects (e.g., slope factor) to assign scores based on

[10] The approach used by Ecology to prepare the PBT working list includes separate toxicity criteria for carcinogenic and non-cancer health effects. The draft definition for "carcinogen" is copied from the MTCA Cleanup Regulation (similar if not identical definitions are found in other Ecology rules and guidance). If the final PBT criteria incorporate the EPA toxicity criteria (or similar approaches), this definition would need to be updated to reflect the current EPA guidance on Carcinogen Risk Assessment.

carcinogenic effects. As part of that process, EPA reviewed a wide range of sources of information on carcinogenicity and identified five sources of information they believed provided a sound basis for characterizing and ranking chemicals based on carcinogenicity. As part of that review, EPA reviewed the quality and attributes of each information source and assigned data preference rankings (highest, high, medium, low, lowest). The EPA data hierarchy preferences or rankings were based on several attributes of the underlying data: (1) extent to which information reflects agency consensus; (2) extent to which data is peer-reviewed; (3) the frequency which values are updated; (4) the extent and quality of documentation; (5) how current the data were; and (6) copyright issues. In general:

- EPA assigned higher preferences to slope factors published in the IRIS database than slope factors included in the HEAST tables.
- EPA assigned higher preferences to slope factors developed by EPA (including values in the database, HEAST tables and other agency lists) than slope factors developed by other organizations (i.e. California Environmental Protection Agency).
- EPA assigned higher preferences to more values that are periodically updated (e.g. IRIS slope factors) than values based on older data that had not recently been reviewed in light of new scientific information (e.g. RQ potency values).

The information sources used by EPA in preparing the WMPT and data preferences assigned to those sources are summarized in Table __.

Table D1: Sources of Information on Human Toxicity (Carcinogenic Health Effects) Used to Prepare WMPT

Data Source	Data Element	Data Preference
Integrated Risk Information System (IRIS) – Environmental Protection Agency	Oral Slope Factors Inhalation Unit Risk	Highest
Health Effects Assessment Summary Tables (HEAST) – Environmental Protection Agency	Oral Slope Factors Inhalation Unit Risk	High
EPA Cancer Oral Slope Values	Oral Slope Factors	High
RQ Potency Factor – Environmental Protection Agency	RQ Potency Factor	Medium
California Environmental Protection Agency	Inhalation Slope Factor Oral Slope Factor	Medium

There are other readily available sources of human toxicity measures that are used by other organizations when evaluating the potential for adverse effects. In most cases, the toxicity measures rely upon the same toxicological information and studies used by EPA or ATSDR to develop reference doses etc. However, there are some differences in the methods used to calculate toxicity measures (e.g. selection of uncertainty factors, identification of points of departure for applying uncertainty factors) that can result in toxicity measures that differ from those published by EPA and ATSDR. Other readily available sources of information human toxicity measures include: (1) the California Office of Environmental Health Hazard

(OEHHA); (2) the National Research Council; (3) Risk Profiles prepared to support listing decisions pursuant to the Stockholm Convention; (4) the World Health Organization; and (5) the peer-reviewed scientific literature.

3 Range of Values Used to Characterize Carcinogenic Potential

There are significant differences in the carcinogenic potential for individual chemicals or chemical groups. To provide a sense of the range of values and differences, Ecology compiled and reviewed the information on carcinogenicity for chemicals or chemical groups that had previously been identified as PBT chemicals by one or more organizations (See Attachment 1).

- Available Information on Carcinogenicity: Out of ninety-one chemicals/chemical groups, 59 had some information available on carcinogenicity. The list included three metals (mercury, lead and cadmium). Forty-one of the chemicals/chemical groups had quantitative measures (e.g. slope factors) that could be compared to the EPA toxicity criteria. Eighteen chemicals had a weight of evidence classification of D (Unclassifiable).
- Weight of Evidence: Fifty-nine chemicals/chemical groups had weight of evidence classifications.
    - Twenty-four (24) chemicals/chemical groups were classified as probable human carcinogens (Weight of Evidence Classification = B);
    - Seventeen (17) chemicals/chemical groups were classified as possible human carcinogens (Weight of Evidence Classification = C)
    - Eighteen (18) chemicals/chemical groups were unclassifiable (Weight of Evidence Classification = D)
- Range of Values: Cancer slope factors ranged from 0.0077 to 150000 (mg/kg/day)-1.
    - Nineteen chemicals or chemical groups had slope factors that exceeded the EPA fenceline value for carcinogens with WOE classifications of A or B (> 4.6 $(mg/kg/day)^{-1}$). An additional two chemicals with WOE classifications of C had slope factors that exceeded the relevant EPA fenceline (> 46 $(mg/kg/day)^{-1}$).
    - The decision to lower the carcinogenicity fencelines would increase the number of chemicals or chemical groups meeting the toxicity criteria. For example, if the fenceline values were lowered to 1 and 10 (mg/kg/day)-1 for probable (WOE = B) and possible carcinogens (WOE = C), respectively, nine additional chemicals or chemical groups would meet the criteria.
    - A decision to establish a qualitative criterion (e.g. all substances classified as known (A) or probable (B) human carcinogens) would result in 24 chemicals or chemical groups meeting the criterion.
- Data Quality Hierarchy: Information used to characterize the 41 chemicals/chemical groupswas obtained from sources that EPA rated at the higher end of their data hierarchy:
    - IRIS Database (Highest) = 20 chemicals or chemical groups;
    - HEAST Database (High) = 11 chemicals or chemical groups; and
    - California Environmental Protection Agency (Medium) = 10 chemicals or chemical groups.

Table D2 - Human Toxicity (Cancer)				
Measure/Data Source	**High (3)**	**Medium (2)**	**Low (1)**	**Data Preference**
EPA WOE Score	A	B or C	NA	NA
IARC WOE Score	1	2A or 2B	NA	NA
NTP WOE Score	NA	CE or SE or EE or P or E	NA	NA.
IRIS Oral Slope Factor (WOE A or B)	> 4.6	4.6 - 0.046	< 0.046	Highest
IRIS Oral Slope Factor (WOE C)	> 46	46 - 0.46	< 0.46	Highest
IRIS Inhalation Unit Risk (WOE A or B)	> 0.0013	0.0013 - 0.000013	< 0.000013	Highest
IRIS Inhalation Unit Risk (WOE C)	> 0.013	0.013 - 0.00013	< 0.00013	Highest
HEAST Oral Slope Factor (WOE A and B)	> 4.6	4.6 - 0.046	< 0.046	High
HEAST Oral Slope Factor (WOE C)	> 46	46 - 0.46	< 0.46	High
HEAST Inhalation Slope Factor (A & B)	> 4.6	4.6 - 0.046	< 0.046	High
HEAST Inhalation Slope Factor (WOE C)	> 46	46 - 0.46	< 0.46	High
EPA Cancer Data Oral Slope Factor (WOE A & B)	> 4.6	4.6 - 0.046	< 0.046	High
EPA Cancer Data Oral Slope Factor (WOE C)	> 46	46 - 0.46	< 0.46	High
RQ Potency Factor (WOE A or B)	> 100	100 to 1.3	< 1.3	Medium
RQ Potency Factor (WOE C)	> 1000	1000 to 1.3	< 13	Medium
Cal/EPA Inhalation Slope Factor (WOE A and B)	> 4.6	4.6 - 0.046	< 0.046	Medium
Cal/EPA Inhalation Slope Factor (WOE C)	> 46	46 - 0.46	< 0.46	Medium
Cal/EPA Oral Slope Factor (WOE A & B)	> 4.6	4.6 - 0.046	< 0.046	Medium
Cal/EPA Oral Slope Factor (WOE C)	> 46	46 - 0.46	< 0.46	Medium